
The vertical structure of ozone variability, as measured by MLS/AURA and ACE and modeled by the CMAM

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Acknowledgements

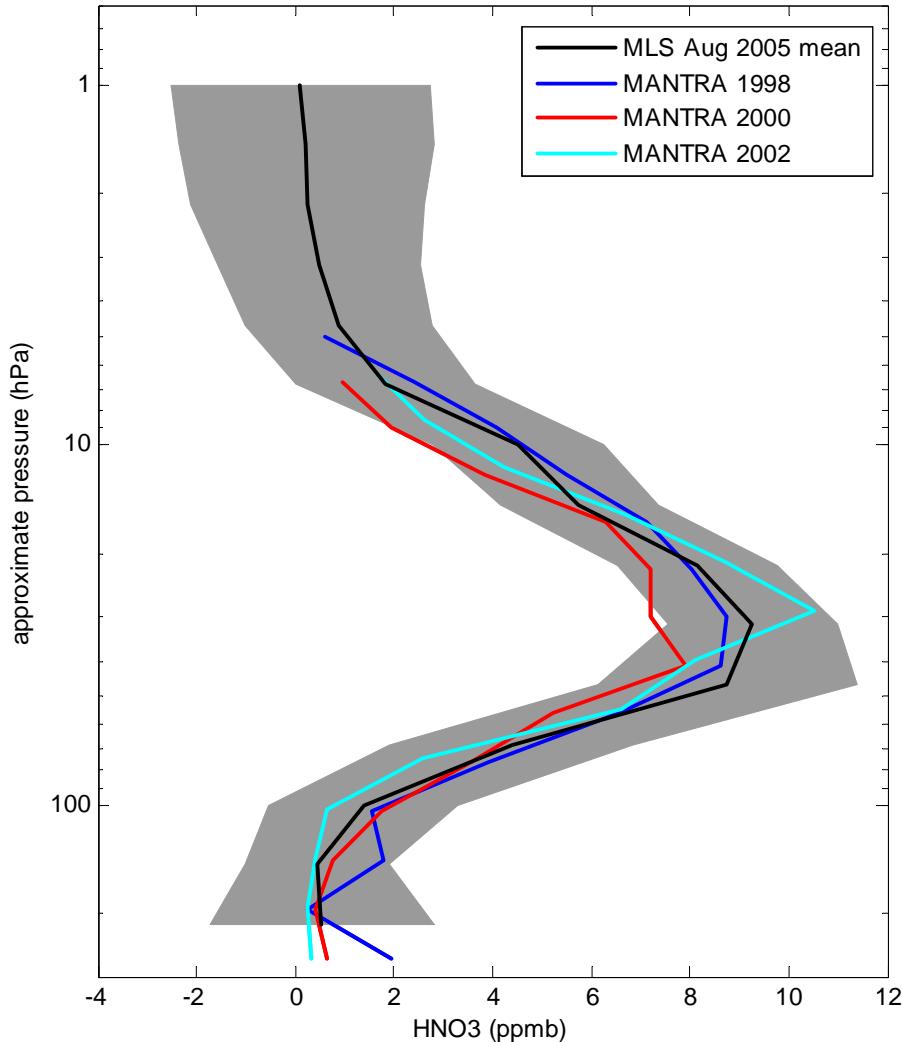
- MLS/AURA, ACE, CMAM, MANTRA science teams
- Canadian Space Agency
- Meteorological Service of Canada
- CREStech/ETech
- CFCAS
- NSERC



Environnement
Canada



Atmospheric variability



- Quantifying natural variability is important:
 - In order to detect trends (e.g. midlatitude O₃, HNO₃ via MANTRA)
 - In the definition of coincident measurements for validation
- Variability comes from sampling in space and time (due to mean spatial gradients and transient perturbations, seasonal cycle...).

Some questions

- How well does our modeled prediction of trace gas variability agree with observations?
- What can the measurement of a variable atmosphere by different instruments tell us about those instruments?

The CMAM (version 7)

- Canadian Middle Atmosphere Model: an upward extension of the CCCma spectral GCM up to roughly 100 km altitude¹.
- Incorporates: radiation, interactive chemistry, gravity wave drag, as well as all the processes in the GCM.
- Full representation of stratospheric chemistry with relevant catalytic ozone loss cycles².
- Heterogeneous reactions are included for sulphate aerosols. No PSCs.
- No QBO, warm winter poles, prescribed SSTs.
- 14 years of output used here.

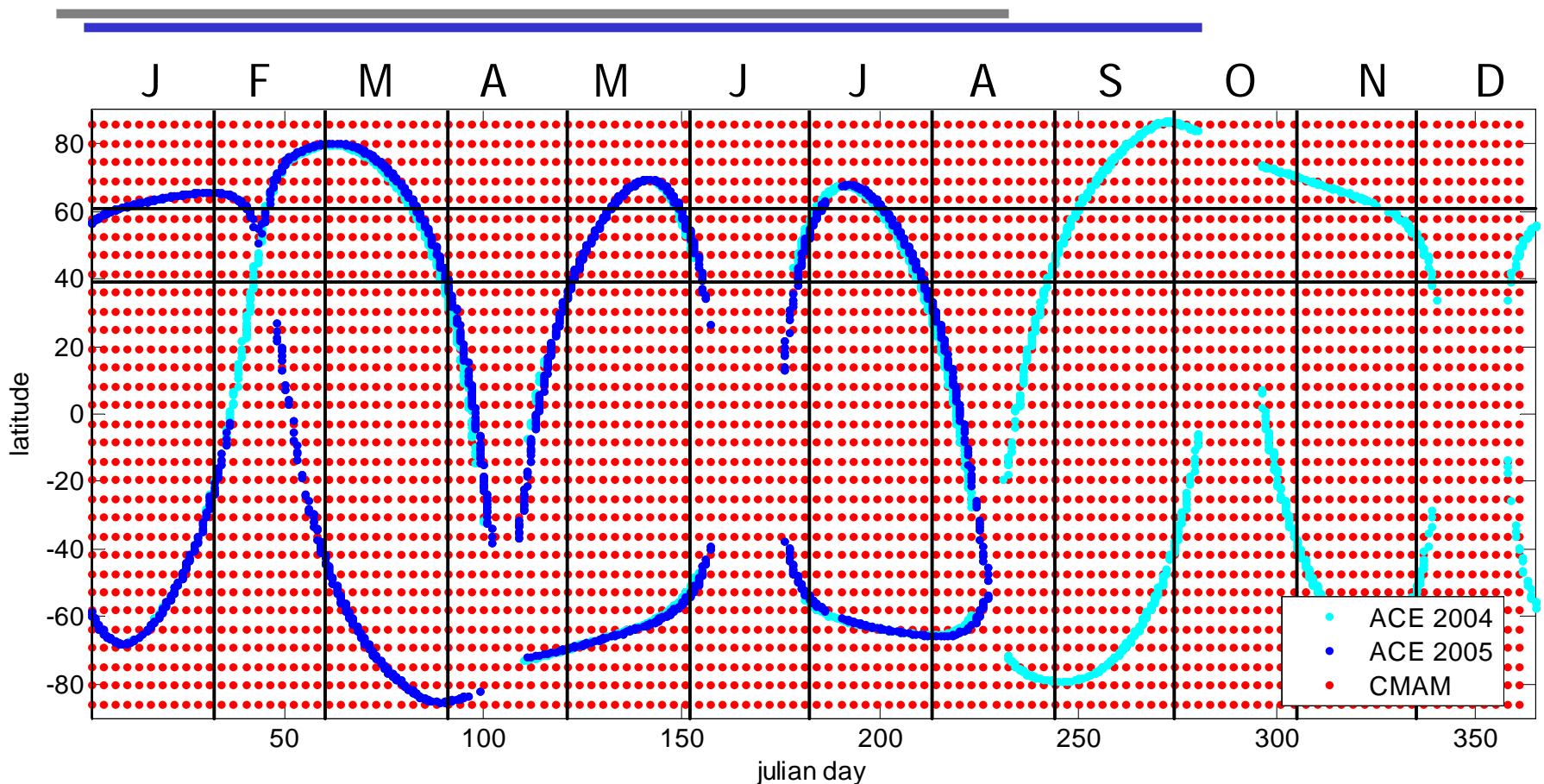
¹ Beagley et al., *Atmos.-Ocean*, 35:293, 1997.

² de Grandpre et al., *Atmos.-Ocean*, 35:385, 1997.

Observations

- MLS/AURA v1.51 L2 O3
 - 2004-08 – 2005-10
 - Ignored data with: negative 12gpPrecision, non zero Status, Quality < threshold.
- ACE-FTS v2.2 O3 (update), pressure
 - 2004-01 – 2005-07
 - Ignored data with: 0 mixing ratio, -888 or -999 flags in profile or errors.
 - ACE profiles are shown in pressure coordinates
 - ACE retrieved pressure is averaged for each z-layer for each subset of ACE data – ACE pressures should be considered approximate.
 - I have not performed a least-squares fit of ACE to the MLS retrieval grid (as described in sec 1.6 of the MLS v1.5 L2 data quality and description document).

Sampling - spatial



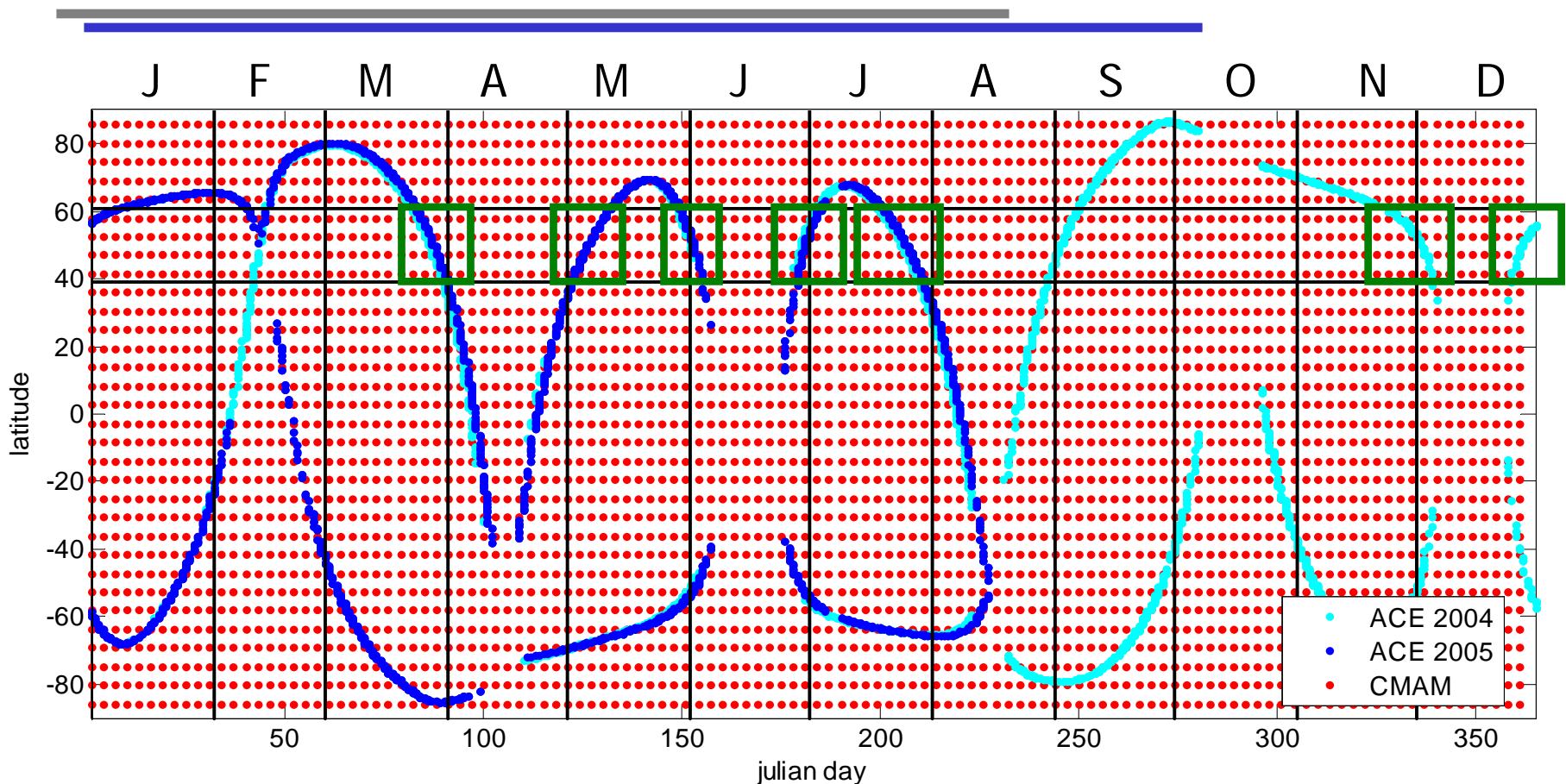
- Focus on northern midlatitudes, 39-61 N
- Take all observations, not just matches

Area weighting*

- Spatial sampling biases addressed through equal-area weighting
 - Randomly remove profiles (or weight them), such that the number of observations (N) in latitude band ϕ to $\phi + \Delta\phi$, N goes as $\cos(\phi)\Delta\phi$
- Has advantage that $P(\chi)$, the area-weighted PDF of discrete sampling of a tracer $\chi(\phi,\lambda)$,
 - is the likelihood of observing a value in the range from χ to $\chi + \Delta\chi$ in some given area, and...
 - is proportional to the area enclosed by the χ and $\chi + \Delta\chi$ contours in a contour plot of the field.

* As described in Sparling, Rev. of Geophys., 38:417-436, 2000.

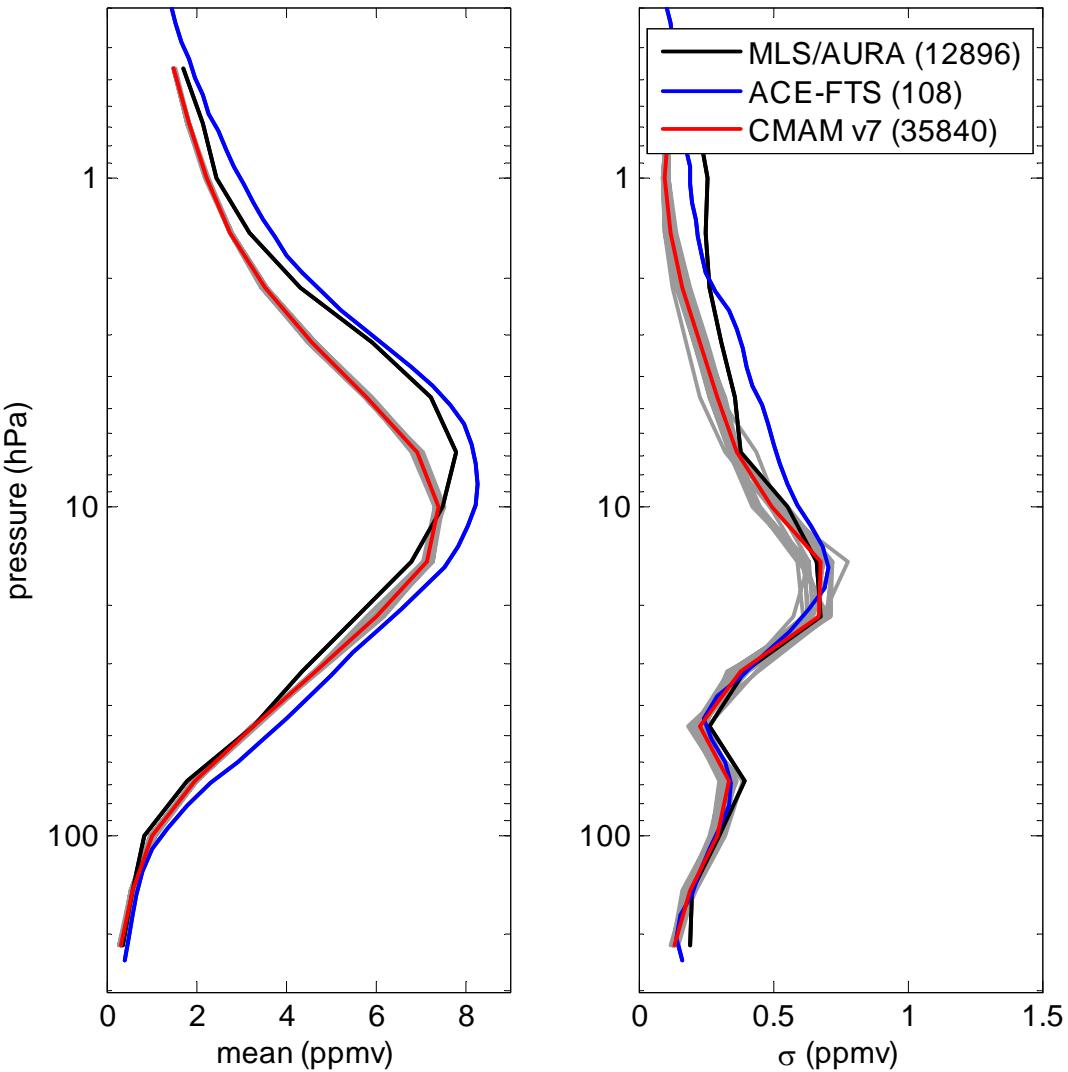
Sampling - temporal



- Monthly statistics calculated for 2004-08 – 2005-10
- Special “fly-by” periods defined for ACE

Area weighted O₃ statistics

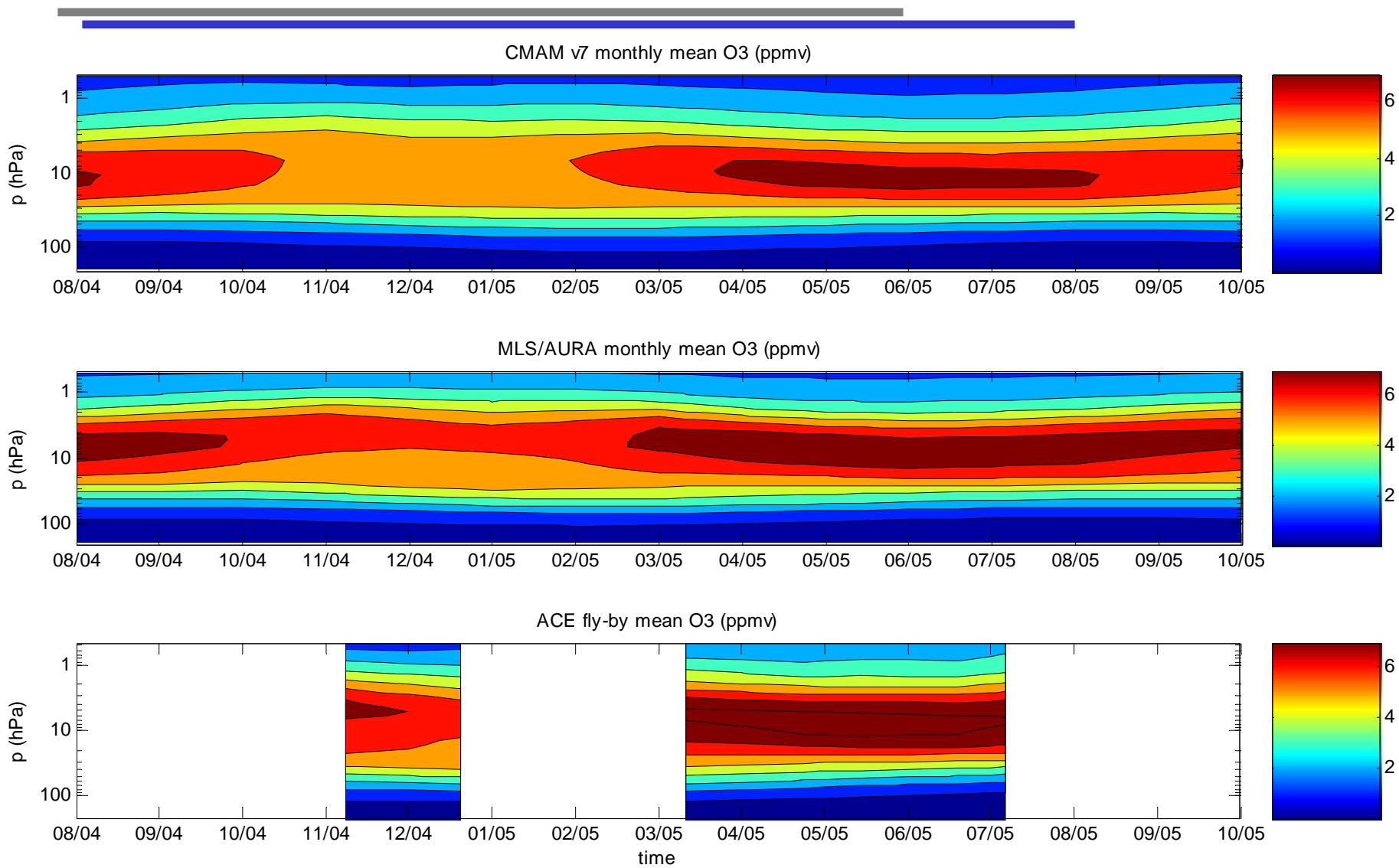
39 - 61°N, 2005-05



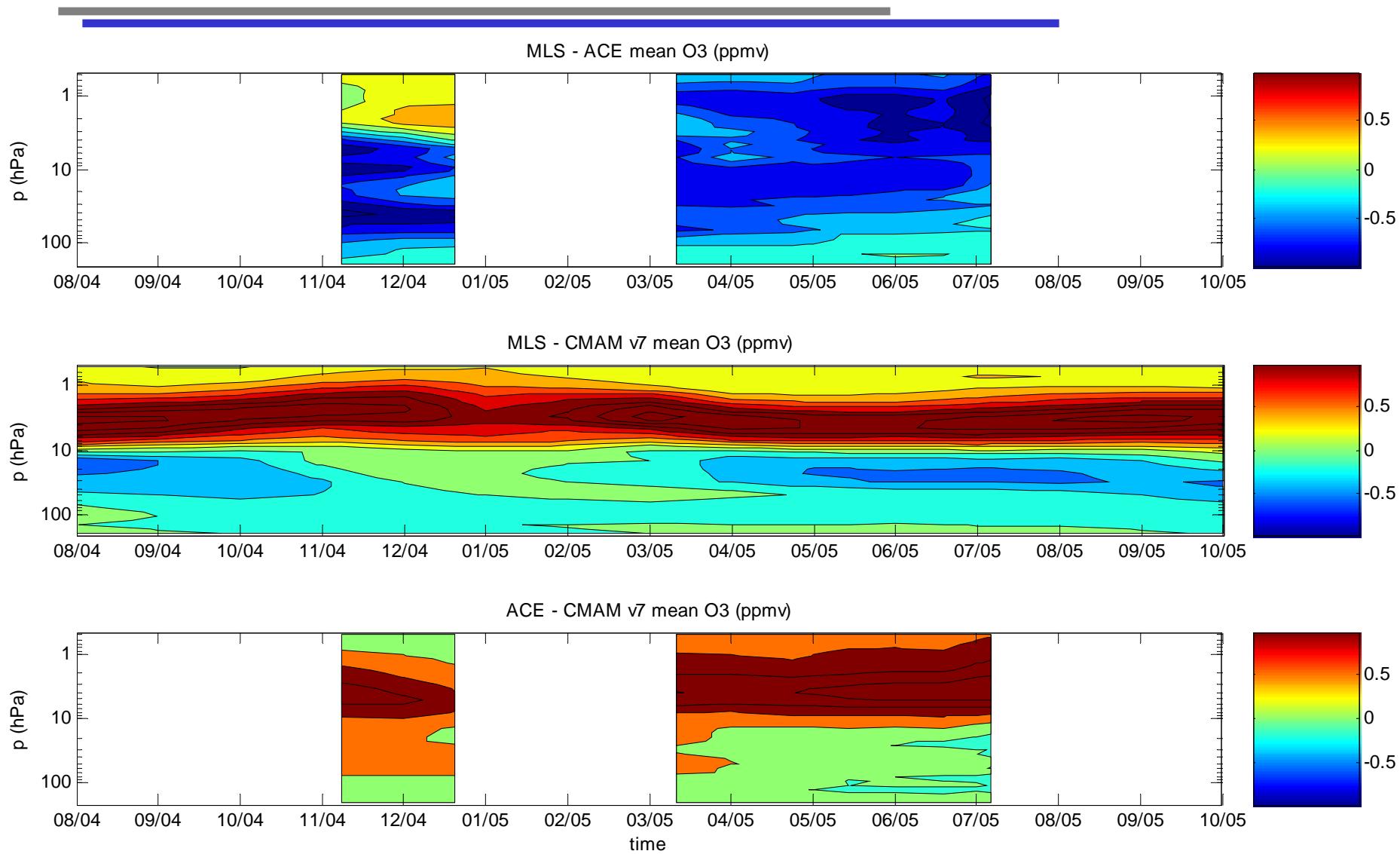
May 2005 monthly mean and standard deviation:

- CMAM climatology in red, yearly stats in grey
- Variability sources include: seasonal cycle, spatial gradients and small-scale structures.
- σ agreement tells you (1) instrument noise < atm variability and (2) instrument Gains comparable

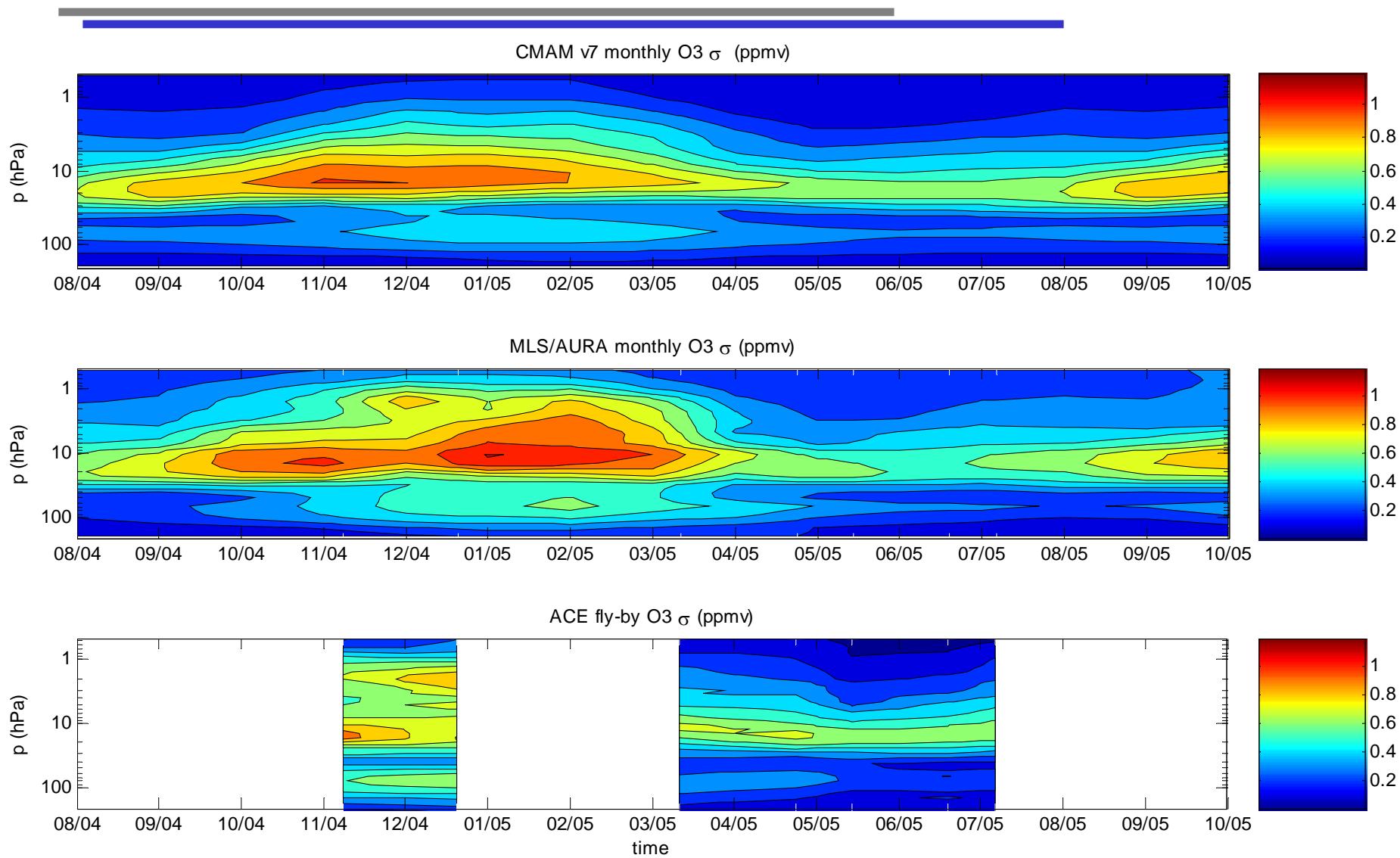
O3 means - time series



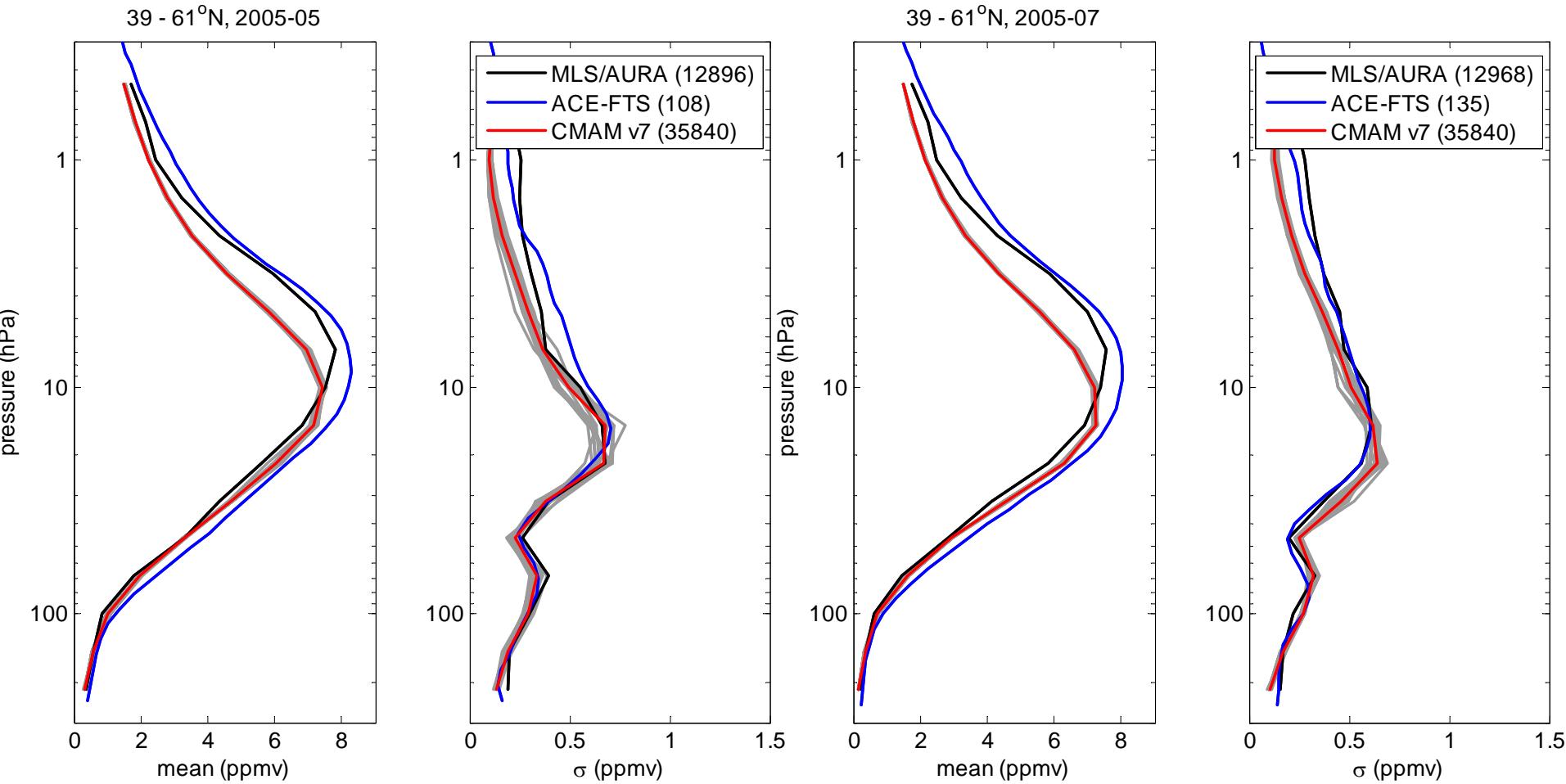
O3 mean differences - time series



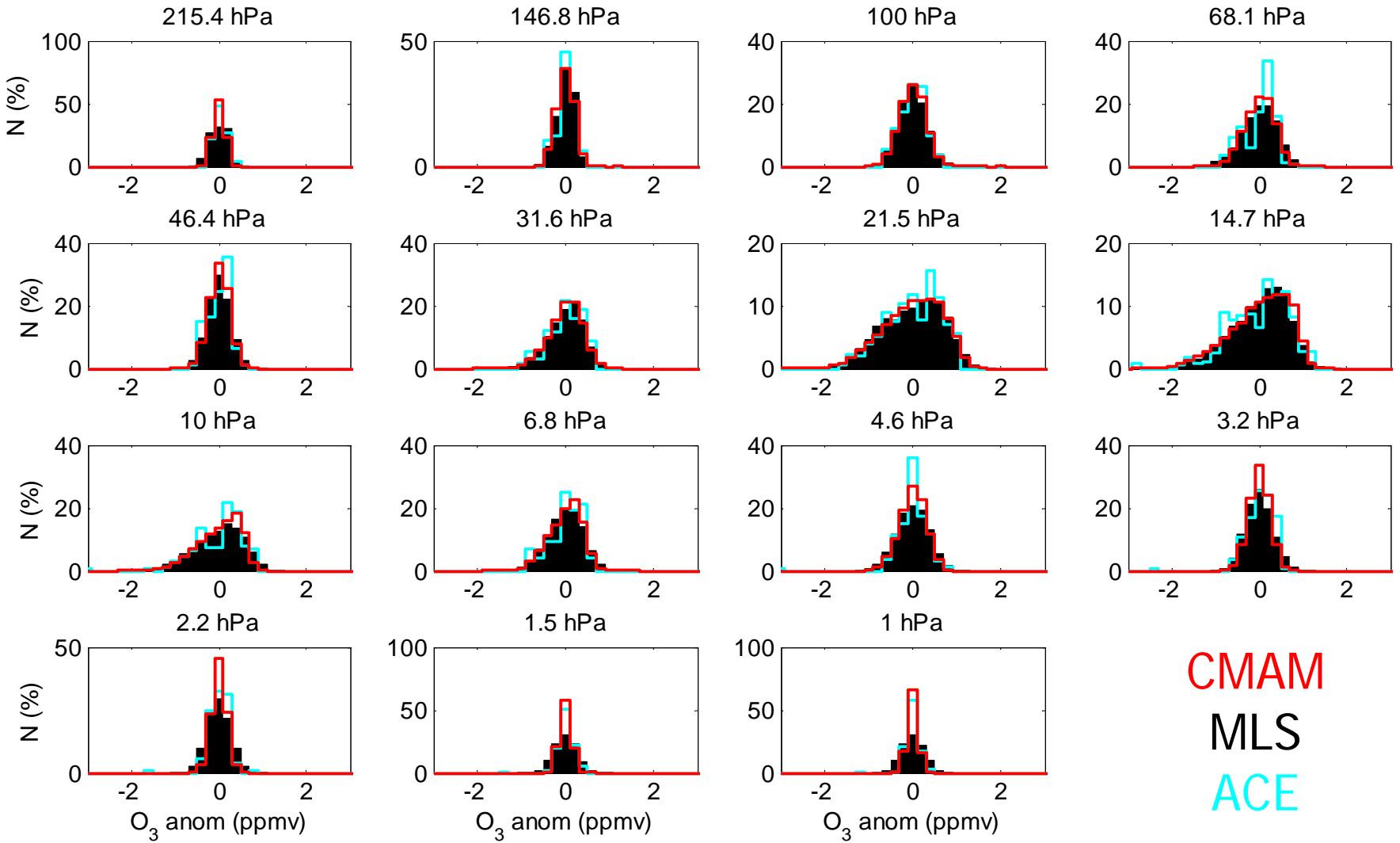
O3 σ - time series



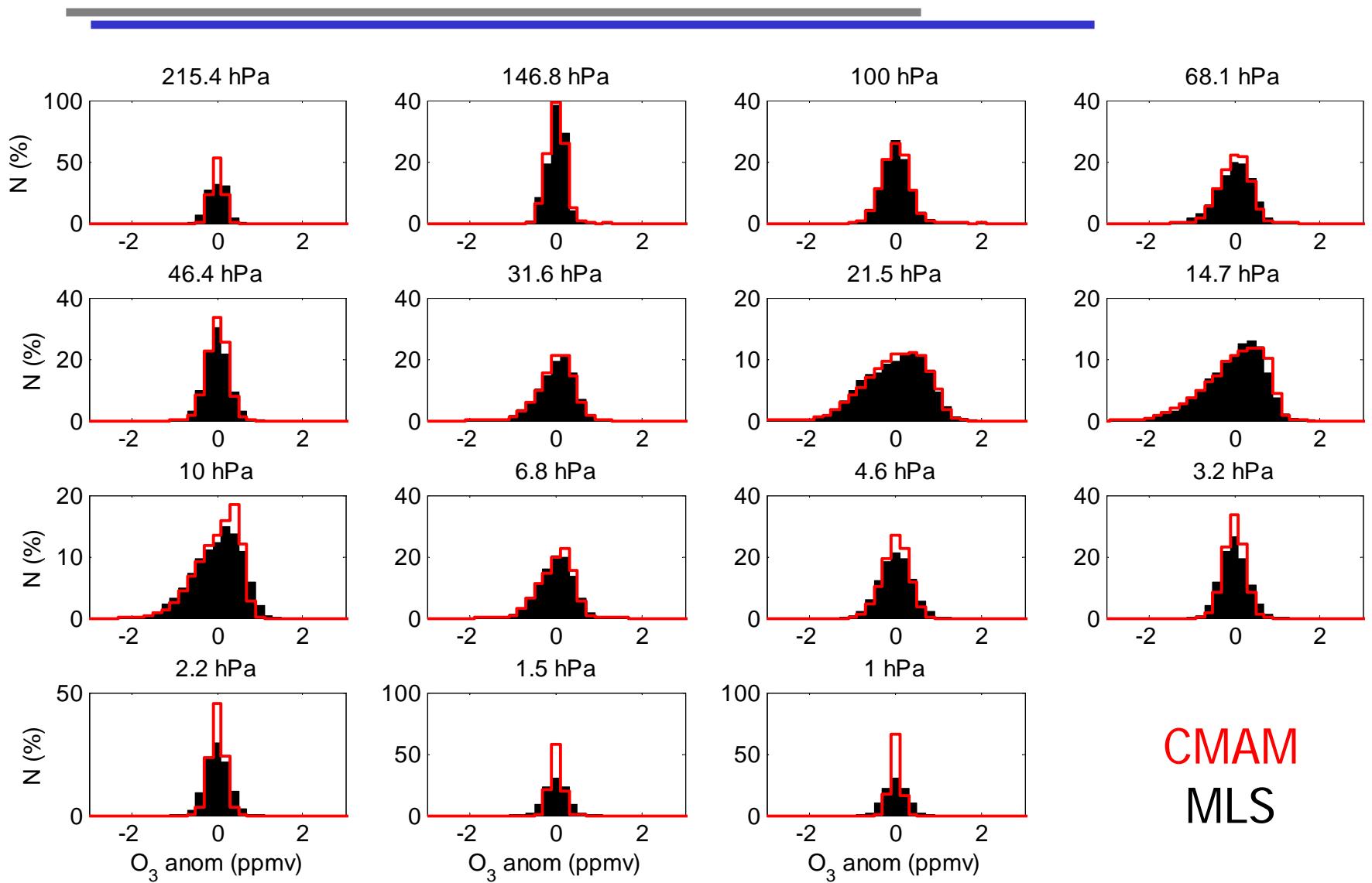
Summer variability



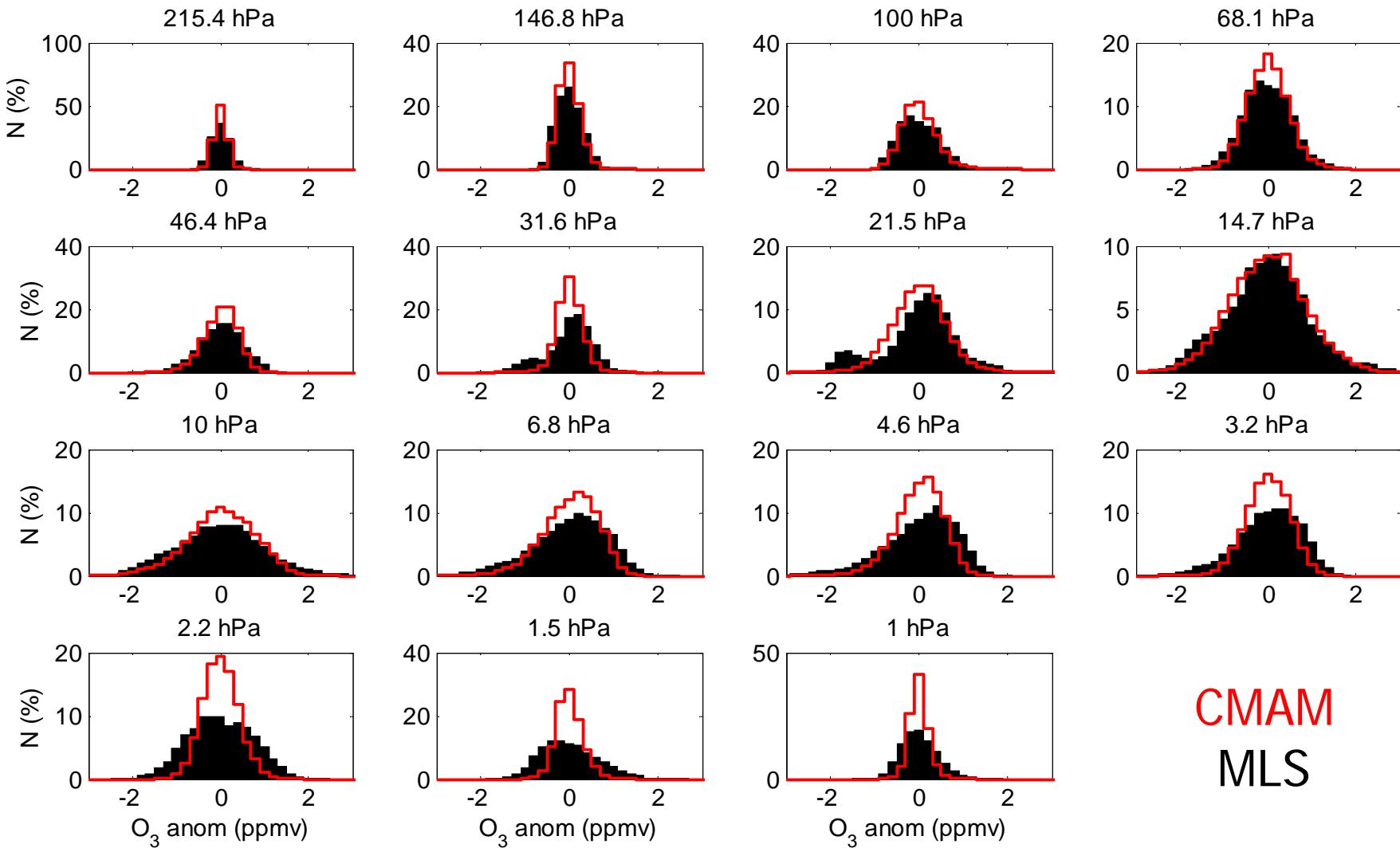
Vertical O₃ anomaly PDFs – May '05



Vertical O₃ anomaly PDFs – May '05



Vertical O₃ anomaly PDFs – Mar '05



CMAM
MLS

Conclusions

- Agreement between MLS and ACE O3 σ profiles:
 - Tells you nothing about retrieval accuracy
 - Tells you little about retrieval precision
 - But, is good circumstantial evidence that the retrievals respond with comparable amplitudes to changes in the atmosphere
- Agreement between the observations and the CMAM O3 σ profiles and PDFs:
 - Is evidence that the model is doing a good job of modeling realistic stratospheric variability (esp. in summer midlatitudes).
 - Gives us confidence in using the model to explore the mechanisms of variability

Atmospheric variability

- True profiles of trace gas species in the middle atmosphere vary with time and space:
 - For reasons radiative, dynamical, and chemical.
- Measured profiles of trace gas species vary:
 - Because the atmosphere does, and because the instrument is not perfect.
- Temporal and/or spatial means of measured profiles will vary:
 - Based on an instrument's incomplete sampling
 - Between instruments, based on differences in measurement technique and assumptions